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Subject: Electrostatic Space Charge System for Reducing Airborne Dust and Pathogens – an Overview

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An electrostatic space charge system was developed in cooperation with The Simco Co. under a Cooperative Research and Development Agreement to reduce airborne dust and microorganisms in poultry areas. The object of the system is to transfer a strong negative electrostatic charge to dust and microorganisms in an enclosed space and to collect the charged particles on grounded trays or plates which are automatically rinsed several times an hour or on surfaces of a room. By removing airborne dust, it is reasonable to expect that the potential for airborne transmission of Salmonella or other potential pathogens would be reduced along with endotoxins, or fungi such as Aspergillus. The system has been shown to have effectiveness comparable to a 95% media filter for removing dust in laboratory experiments in hatching cabinets and transmission cabinets and equal or better effectiveness for removing airborne bacteria and Salmonella. Hatching cabinet experiments have been conducted at the Southeast Poultry Res. Lab, at the Richard Russell Res. Center in cooperation with microbiologists there, and also for several months in cooperation with commercial hatcheries with similar results. Experiments conducted in a 15 x 22 ft (3300 ft^3) isolation room with caged layers showed reductions of airborne Salmonella enteritidis (SE) of approximately 95% over a test period of 10 days when the room was treated with the space charge system. Another effect of the space charge -- besides reducing dust and microorganisms which are already airborne, is to keep surface dust near its source. For example, loose dust on the floor of a treated room would tend not to become airborne because as soon as it left the floor it would be charged and re-attracted to the floor. Basic lab experiments indicate that there is also a strong sterilizing effect of the charge which kills airborne and surface Salmonella. The kill rate on airborne and surface SE at close range has been shown to be 96% or more. Determination of the charge density required for killing Salmonella and other pathogenic bacteria is part of ongoing basic research.

A patent application was filed July 28, 1998 for the system, and patent claims were accepted in February, 2000. An exclusive license for poultry applications has been approved with BioIon, Inc. to manufacture and distribute the system. The BioIon system was tested in a commercial Jamesway hatching cabinet and compared to a control cabinet with hydrogen peroxide disinfection. On the average in experiments ranging over 5 hatches, the BioIon system reduced Salmonella by four fold compared to the control, and it reduced Enterobacteriaceae by 94% compared to the control. A large scale hatchery study with the system involving air sampling for dust, pathogens fungi, early mortality, Salmonella infection at one week of age, and fluff sampling is underway with a large poultry integrator. Another study is underway with a primary breeder company. The system has also been shown to reduce biofilms, developed from poultry carcass rinses on stainless steel surfaces, up to 99.8%. Interest in the system as a food safety intervention approach has been expressed by poultry companies in the U.S., Mexico, South America, Costa Rica, Japan, Korea, Israel and Holland. A system for a typical commercial sized 15,000 egg hatching cabinet currently costs about $2,600 installed. Advantages for the hatchery application include reduced pathogens in the air of the hatching cabinet which should lead to improved food safety for the consumer, reduced potential for cross contamination of other areas of the hatchery, reduced cleanup of exhaust ducts and open areas of the hatchery, and improved air quality in the hatchery exhaust. Grant proposals are pending for studies to determine effectiveness in a breeder house and to determine the mechanisms and LD-50 parameters for inactivation of SE. Recognition of the technology includes a 1999 Superior Technology Transfer Award in 1999 and inclusion as an intervention approach (Objective 7.1.4) in the President's Egg Safety Action Plan.

Other applications include any enclosed space where moderate to large concentrations of airborne dust or pathogens are being generated or introduced. The system also works equally well for reducing airborne particulates and pathogens in enclosed areas with normal concentrations of dust/pollen/bacteria, etc. All of the applications have potential for improving human health as well.

(Related Publications, Patents, Presentations: see next page)

Related Publications and Patents

1. Mitchell, B.W., P.S. Holt, and K.H. Seo. Effectiveness of electrostatic space charge for reducing dust in a caged layer room. J. Appl. Poultry Res. In Press.
2. Gast, R.K., B.W. Mitchell, P.S. Holt. 1999. Application of negative air ionization for reducing experimental airborne transmission of salmonella enteritidis to chicks. Poultry Sci. 78:57-61.
3. Holt, P.S., B.W. Mitchell, K.H. Seo, and R.K. Gast. 1999. Use of negative air ionization for reducing airborne levels of Salmonella enterica serovar Enteritidis in a room containing infected caged layers. J. Appl. Poultry Res. 8:440-446.
4. Mitchell, B.W. 1998. Effect of negative air ionization on ambient particulates in a hatching cabinet. Applied Engr. in Agric. 14(5):551-555.
5. Mitchell, B. W., R. J. Buhr, M. E. Berrang, J. S. Bailey, and N. A. Cox. 1998. Reduction of airborne bacteria in the hatching cabinet with an electrostatic space charger. Poult. Sci. 77 (S1):151.
6. Mitchell, B.W. and H.S. Stone. 1998. Electrostatic reduction system for reducing airborne dust and microorganisms. Patent Application Serial No. 09/122,850. Filed July 28, 1998. Claims accepted Feb 25, 2000 by U.S. Patent Office.
7. Mitchell, B.W. 1997. Effect of airflow on ion distribution for potential dust reduction applications. J. of Agricultural Safety and Health. 3(2):81-89.
8. Mitchell, B.W. and King, D.J. 1994. Effect of negative air ionization on airborne
9. transmission of Newcastle disease virus. Avian Dis. 38:725-732. 1994.

Related Recent Presentations

Mitchell, B.W., P.S. Holt, and K.H. Seo. Effectiveness of electrostatic space charge system for reducing dust in a caged layer room. AgEng 2000, Paper No. 00-AP-033, Warwick, U.K., July 2, 2000.

Mitchell, B.W. Electrostatic space charge for pathogen intervention. Introduction to HACCP: broiler live production. Gainesville, Ga, November 4, 1999.

Mitchell, B.W. Negative air ionization system for sanitizing and fluff removal in poultry areas. Georgia Poultry Conference, Athens, Ga, September 28-29, 1999.

Mitchell, B.W. Electrostatic space charge system -- principals of operation and application for reducing airborne pathogens and dust in poultry areas. Ga Vet Med Assoc Meeting, Jekyl Island, Ga, June 18-19, 1999.

Mitchell, B.W. Performance of an electrostatic dust reduction system in a commercial hatchery. Dust Control in Animal Production Facilities, International Symposium, Denmark, 30 May - 2 June, 1999.

Mitchell, B.W. Electrostatic space charge system for dust and pathogen removal in commercial hatching cabinets. Southern Poultry Science, January 18-19, 1999, Atlanta, Ga.

Mitchell, B.W., R.J. Buhr, M.E. Berrang, J.S. Bailey, and N.A. Cox. Reduction of airborne bacteria in the hatching cabinet with an electrostatic space charge. Southern Poultry Science, January 19-20, 1998, Atlanta, Ga.

Mitchell, B.W., R.J. Buhr, M.E. Berrang, N.A. Cox, and J.S. Bailey. Characterization and reduction of airborne particulates in the hatching cabinet with an electrostatic space charge. Southern Poultry Science, January 19-20, 1998, Atlanta, Ga.

Mitchell, B.W. 1998. Reduction of airborne pathogens and dust with an electrostatic space charge system. 19th Annual USDA Food Safety Res. Planning Meeting. December 1-3, 1998, Athens, Ga.

Mitchell, B.W. Reduction of airborne pathogens and dust with an electrostatic space charge and demonstration. Annual USDA Food Safety Research Planning Meeting. December 1-3, 1998. Athens, Ga.

Mitchell, B.W. Engineering controls for minimizing airborne poultry disease transmission. ARS Poultry Research Workshop sponsored by U.S. Poultry and Egg Assoc., June 17-18, 1997. Athens, Ga.

Mitchell, B.W. Effect of space charge and reeintrainment on dust reduction in metal and plastic hatching cabinets. Electrostatics Society of America International Meeting. Athens, Ga, June, 1997

Electrostatic Space Charge System for Reducing Salmonella enteritidis

Approach:

- *Reduce SE levels in the air by removing bacteria-laden dust, and to some extent by killing effect*
- *Reduce SE levels on surfaces by killing effect*

Expected Results:

- *Reduce SE transmission between birds in breeder houses, hatchers, and production houses*
- *Reduce SE contaminated eggs in breeder houses*
- *Reduce house to house and cabinet to cabinet transmission and cross contamination*
- *Improve bird and animal caretaker health by improving air quality*

Concepts for Pathogen and Dust Reduction Using Electrostatic Space Charge

- *Introduce a strong negative electrostatic charge into the space*
- *Charge airborne dust negatively*
- *Charging increases precipitation rate*
- *Charged dust strongly attracted to room surfaces or specialized collector plates*
- *Space charge approach not as subject to fouling or plugging as recirculating or pass through filters*

TYPICAL DUST SOURCES

- *LITTER*
- *ANIMALS (skin, hair, feathers, etc.)*
- *FEED*
- *OUTSIDE AIR (dust, pollen, etc.)*
- *SECONDARY DUST (re-suspended from building surfaces)*

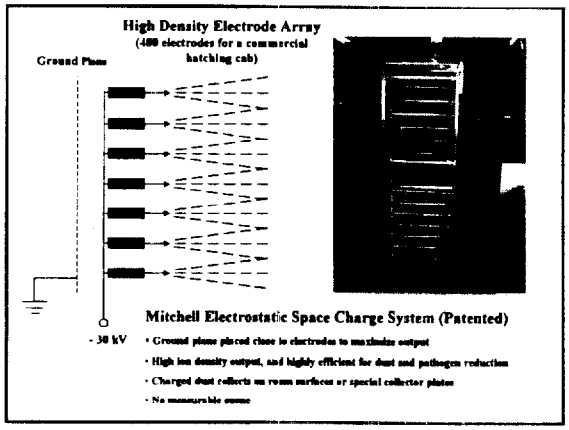
HATCHING CABINET PROBLEMS

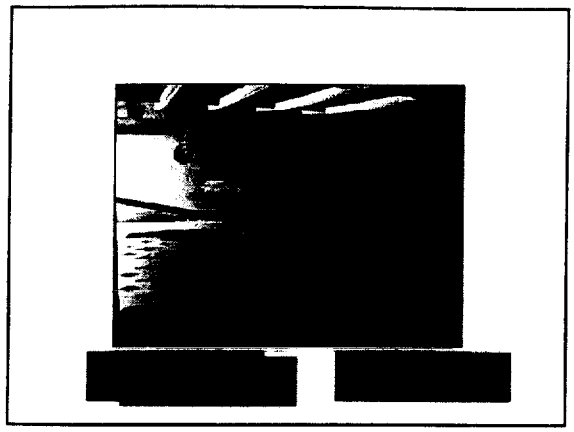
- *Primary source for Salmonella contamination*
- *Chicks generate large amount of dust from pip through day 21.*
- *One contaminated egg (Salmonella) can contaminate all chicks in a hatching cabinet*

DUST AND DISEASE

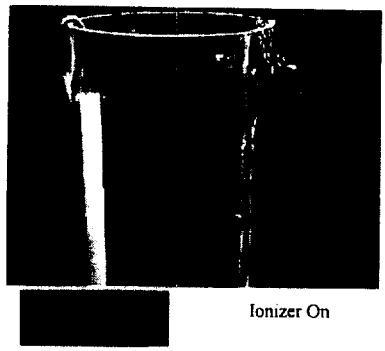
Recirculation of air through a high efficiency filter in a broiler room

- *reduced dust by factor of 2*
- *reduced bacterial count by factor of 100*

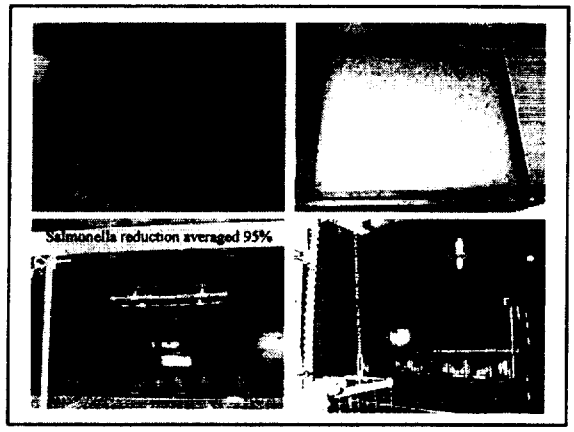




Prototype Fluff Collector



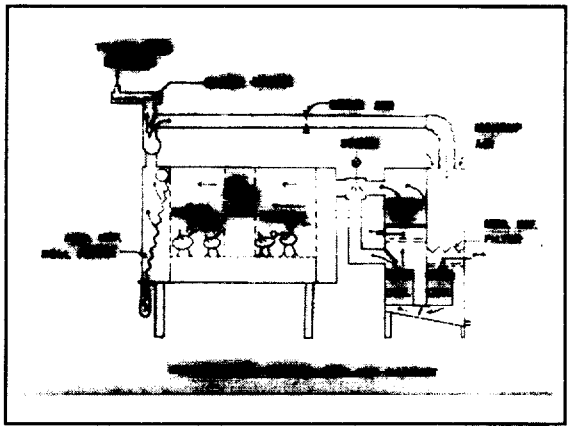
Ionizer On

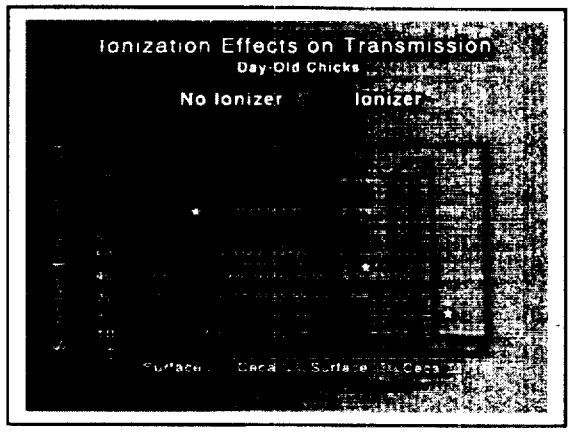


Aerosol route enhances contamination of intact eggs and muscle by Salmonella typhimurium: *Leach, et al., FEMS Microbiology Letters, 1999*

Salmonella positive eggs with

- *Oral challenge: 1.7%*
- *Low Aerosol challenge: (8 x oral) 13.8%*
- *High Aerosol challenge: (15 x oral) 25.4%*





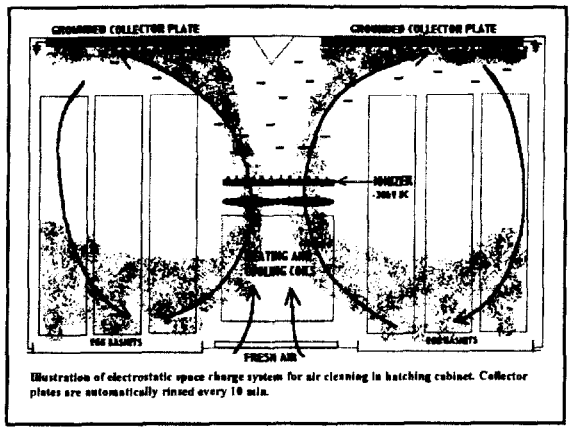
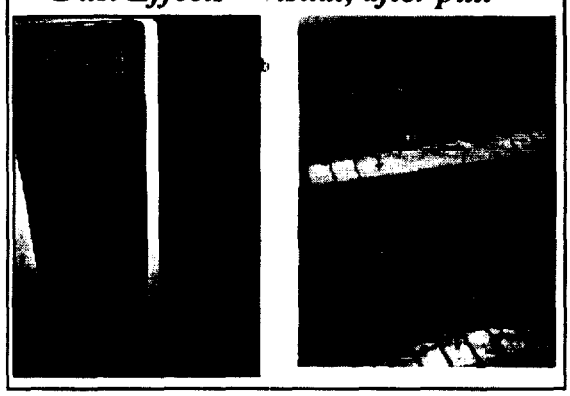
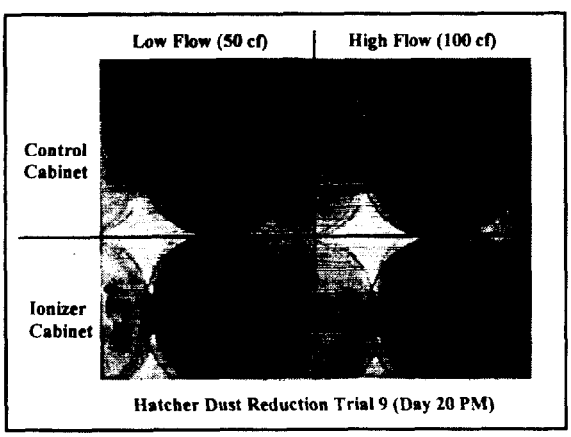


Illustration of electrostatic space charge system for air cleaning in hatching cabinet. Collector plates are automatically rinsed every 10 min.

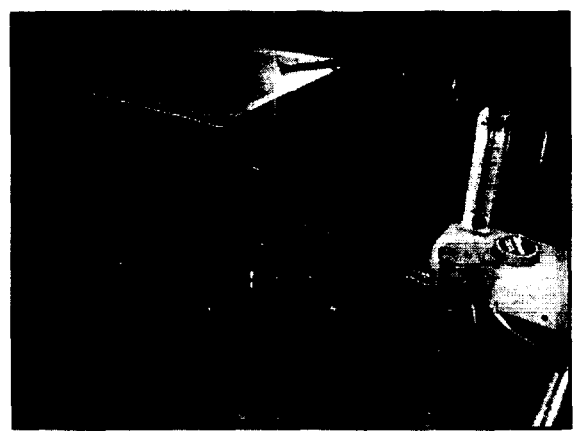
Ionizer/Collector for Jamesway Hatching Cabinet

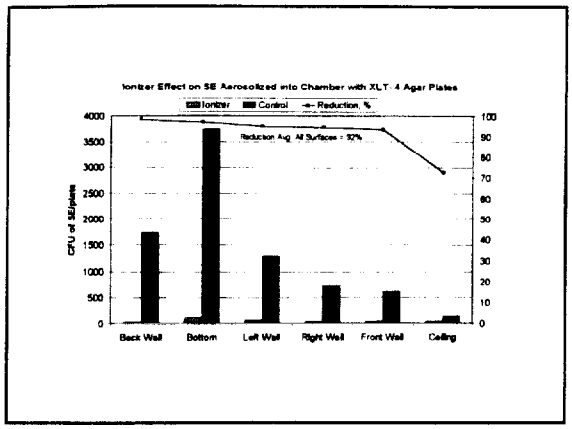
Dust Effects – visual, after pull

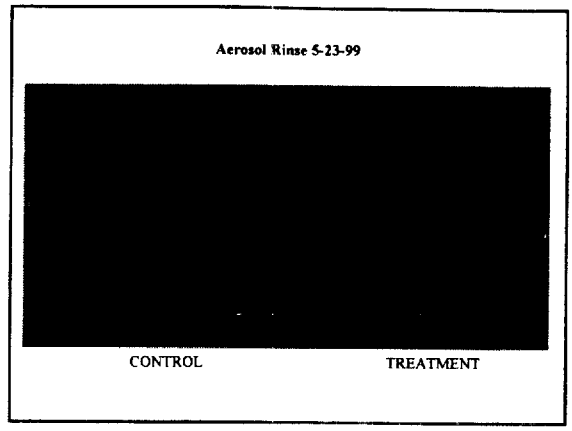




Hatcher Dust Reduction Trial 9 (Day 20 PM)







Biofilm Reduction Results

- *Biofilms from broiler carcass rinses were developed on stainless steel discs and treated with electrostatic space charge system (ESCS)*
  - *Bacterial counts (cfu) reduced 99.8% in 3 hours, 97.3% in 2 hours*
  - *Implication: ESCS could be important, non-chemical sanitizing technology for surfaces*
  - *Questions remaining: LD-50 dose, minimum charge density required, surface conductivity effects, effects on specific pathogens*

Relevance of Ionizer System

- *Superior Technology Transfer Award by ARS in 1999 for "Reducing Dust and Pathogens in Enclosed Poultry Areas"*
- *Ion Air Scrubbers in Hatcheries listed as an "Intervention Strategy or Technology" (Objective 7.1.4) in the President's Egg Safety Action Plan*
- *Since ionizer application possibilities are broad, suggested name for technology = Electrostatic Space Charge*

Tech Transfer Summary

- *Patent claims accepted: Feb, 2000*
- *Two companies collaborating as Biolon to license/manufacture for poultry applications*
- *Commercial trials completed with two commercial broiler integrators in hatcher applications, trials in progress with three others*
- *Several other U.S. and Japanese companies interested in hatchery and breeder houses application*

Potential Application Areas for SE Control

- *General: Inactivation of airborne and surface SE (grant proposal pending)*
- *Breeder House (grant proposal pending)*
- *Production House*
- *Egg rooms*
- *Hatching cabinets*